ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 10, April 2015

VLSI Architecture of Centre of Gravity Based Defuzzifier Unit

Roshana M. Pusdekar, Anil B. Bawaskar,
Priyadarshini College of Engg. , Dept. of Electronics Nagpur, India

Abstract— In fuzzy control systems, fuzzification and defuzzification are two important procedures. Defuzzification is an important part in the implementation of a fuzzy system. The fuzzy data obtained from the fuzzification process is not suitable for real time applications, this fuzzy data can be converted into crisp data, and this process is known as defuzzification. The Fuzzy inference processor are becoming widely used in the field of real time control in various application, Due to easy implementation fuzzy logic by using very large scale integration technology and implement the fuzzy inference system with VHDL code and tanner tool .Defuzzifier is used for converting fuzzy grade to Crisp output so that to use this designed system in a real time application so that the speed of the process increases to a very far level due to which the overall efficiency must be increased so that it should be very beneficial for user The process of defuzzification is very important and has a significant impact on the overall Performance of a fuzzy inference system. The proposed defuzzifier is based on the centre of gravity defuzzification method but weighted average method is generally being used because of simplicity there is a disadvantage in it, cannot be used for a asymmetrical output membership functions. Due to this reason there is a need of implementation of the VLSI architecture design of centre of gravity based defuzzifier. In this paper we are study weighted average method which is overcome by center of gravity method and detail study center of gravity based defuzzifier method , the work is done in tanner tool software.

***Index Terms*—Center of gravity; Defuzzification; Fuzzy processor; Fuzzification.**

I. INTRODUCTION

The modern concept of fuzzy sets was introduced by Lotfi Zadeh in his work "Fuzzy Sets" which described the mathematics of fuzzy set theory nearly three decades ago. Although a relatively new theory, fuzzy logic has been used in many engineering applications because being considered as a simplistic solution available for the specific problems. Fuzzy systems have high potential to understand. In this work, VLSI architecture of a defuzzifier has been proposed. The defuzzifier designed is based on the centre of gravity Defuzzification. Generally, weighted average method has been used for defuzzification and VLSI architectures for weighted average defuzzification has been designed and developed many times. But weighted average method cannot be used for an asymmetrical output membership functions. Therefore the COG method is being used and COG method is the most prevalent and physically appealing of all the defuzzification methods. In this paper VLSI architecture of defuzzifier by using center of gravity method is used and implemented in tanner tool software.

II. FUZZY SYSTEMS

Fuzzy systems consist of three units' membership functions of system's input, rules and membership functions of system's output. The Membership functions are used to define the fuzzy sets of inputs and outputs, the rules are used to define the relationships between input fuzzy sets and output of fuzzy sets. The fuzzy system's output passes through three units is as follow and shown in Figure.1

1. Fuzzification – convert classical data or crisp data into fuzzy data or Membership Functions (MFs)
2. Fuzzy Inference Process – combine membership functions with the control rules to derive the fuzzy output
3. Defuzzification – The fuzzy data obtained from the Fuzzification process is not suitable for the real time applications and have to be converted into crisp form.

All machines can process crisp or classical data such as either '0' or '1'. In order to enable machine, the crisp input and output must be converted to linguistic variables with fuzzy components. For example, to control an air conditioner system the input temperature and the output control variables must be converted to the associated linguistic variables such as 'HIGH', 'MEDIUM' or 'LOW' and 'FAST','MEDIUM' or 'SLOW', The first linguistic variables are corresponding to the input temperature and the second is associated with the rotation speed of the operating motor. The input and the output must also be converted from crisp data to fuzzy data; all of these are performed by Fuzzification process. In the second step, the fuzzy inference process combine the Membership Functions with the control rules to derive the control output and arrange those outputs into a table that table is called as lookup table. The control rule is the core of the fuzzy inference process and those rules are directly related to a human being's intuition and feeling For example in the air conditioner control system, if the temperature is high, the heater in the air conditioner should be turned off the heat driving motor should be slowed down. Different methods such as Center of Gravity (COG) or Mean of Maximum (MOM) are utilized to calculate the associated control output and each control output should be arranged into a table called lookup table In the third step, during an actual application a control output should be selected from the lookup table developed from the last step based on the current input. Furthermore, that control output should be converted from the linguistic variable back to the crisp variable and output to the control operator, the process is called defuzzification The process of the fuzzy system output derived is as follows: [9]

1. The Fuzzification unit finds the value of all input membership functions at corresponding given crisp inputs and the output of this unit will be a set of fuzzy sets.

2. The inference unit has three tasks:

a. Uses the antecedent parts of the rules to combine input fuzzy sets.

b. Uses the consequent parts of the rules with the output of previous task to imply the fuzzy sets of the output.

c. Aggregates the output fuzzy sets in one output fuzzy set.

3. The defuzzification unit finds the crisp output value at which the output membership function has the fuzzy set obtained from previous stage.

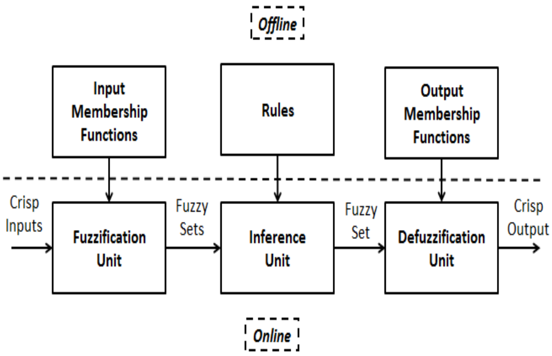

Fig 1. The Units of Fuzzy System

III. DEFUZZIFICATION PROCESS

The fuzzy data obtained from the Fuzzification process is not suitable for the real time applications and have to be converted into crisp form. This process is known as defuzzification and it reduces the collection of membership function values into a single quantity. Figure 2 shows the block diagram of a defuzzifier circuit. X is the fuzzy input to the defuzzifier, which comprises of elements and their associated membership functions. The defuzzifier block is having an architecture intact based the defuzzification techniques as mentioned above to extract the defuzzified or the crisp value, this crisp output values only can be used to control various processes or mechanisms

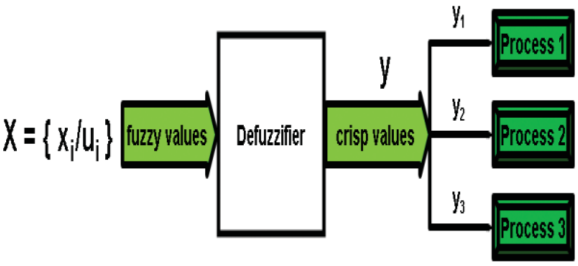

Fig 2: Block diagram of a defuzzifier

IV. DEFUZZIFICATION METHODS

A mapping from a space of fuzzy control action defined over an output universe of discourse into a space of non-fuzzy (crisp) control actions. A defuzzifier is necessary when fuzzy reasoning of the first type is used

The defuzzification methods are used as follow

- Max-membership principle.
- Centroid method.
- Weighted average method.
- Mean-max membership.
- Centre of sums.
- Center of largest area.

These methods have their own applications, advantages and disadvantages. The researchers have developed various architectures of defuzzifier depending on what application the fuzzy processor or the fuzzy controller is being designed.

V. CENTER OF GRAVITY METHOD

The Center of Gravity method (COG) is the most popular defuzzification technique and is widely utilized in actual applications. The weighted average of the membership function or the center of the gravity of the area bounded by the membership function curve is computed to be the crispest value of the fuzzy quantity. For example if the heater motor *z* is rotated FAST. The COG output can be represented as in Equation 1

$$COG\ (FAST) = \Sigma\, \mu_{FAST}\,(z).z / \Sigma\, \mu_{FAST}\,(z) \qquad (1)$$

If *z* is a continuous variable, this defuzzification result is shown in Equation 2

$$COG\ (FAST) = \int \mu_{FAST}\,(z).z / \int \mu_{FAST}\,(z) \qquad (2)$$

Weighted average method cannot be used for an asymmetrical output membership functions, therefore, the COG method is being used. Centre of gravity method. This method is more complex, but is the most accurate method among all Equation 4 shows the model for the COG based defuzzification

$$YCOG = \int \mu_C\,(z).z / \int \mu_C\,(z) \qquad (3)$$

$$YCOG = N/D \qquad (4)$$

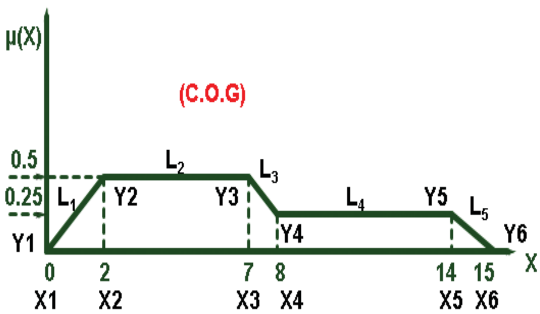

Fig 3. Model for center of gravity

To develop the architecture for the defuzzification process based on COG, consider the defuzzification for the model shown in Figure 3. To calculate the defuzzifier value for Figure 3Apply equation 3 and 4 to the entire figure3. Since Figure 3 comprises of different line segments connected

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 10, April 2015

together and having different slopes, therefore, the architecture developed must take into account all these parameters. from Figure 3 that there are three types of lines, first with positive slope, like L1, second with zero slopes, like L2 Applying equations 3 and 4 to the model level1 (L1) and L4 and third with negative slopes, like L3 and L5.

$$N1 = \int_{X1}^{X2} \left(\frac{Y2-Y1}{X2-X1} X\right) X dX$$

$$D1 = \int_{X1}^{X2} \left(\frac{Y2-Y1}{X2-X1} X\right) dX$$

Applying equations 3 and 4 to the model level2

$$N2 = \int_{X2}^{X3} \left(\frac{Y3-Y2}{X3-X2} X + C1\right) X dX$$

$$\text{Since } Y3 = Y2 \Rightarrow N2 = \int_{X2}^{X3} (C1)\, X dX = \int_{X2}^{X3} 0.5\, X dX$$

$$D2 = \int_{X2}^{X3} \left(\frac{Y3-Y2}{X3-X2} X + C1\right) dX = \int_{X2}^{X3} 0.5\, dX$$

Applying equations 3 and 4 to the model level3

$$N3 = \int_{X3}^{X4} \left(\frac{Y4-Y3}{X4-X3} X\right) X dX$$

$$D3 = \int_{X3}^{X4} \left(\frac{Y4-Y3}{X4-X3} X\right) dX$$

Applying equations 3 and 4 to the model level4

$$N4 = \int_{X4}^{X5} \left(\frac{Y5-Y4}{X5-X4} X + C2\right) X dX$$

$$\text{Since } Y4 = Y5$$

$$N4 = \int_{X2}^{X3} (C2)\, X dX = \int_{X2}^{X3} 0.25\, X dX$$

$$D4 = \int_{X4}^{X5} \left(\frac{Y5-Y4}{X5-X4} X + C2\right) dX = \int_{X2}^{X3} 0.25\, dX$$

Applying equations 3 and 4 to the model level5

$$N5 = \int_{X5}^{X6} \left(\frac{Y6-Y5}{X6-X5} X\right) X dX$$

$$D5 = \int_{X5}^{X6} \left(\frac{Y6-Y5}{X6-X5} X\right) dX$$

The final defuzzification is given by using center of gravity method

YCOG= (N1+N2+N3+N4)/ (D1+D2+D3+D4)

VI. CONCLUSION

In this paper VLSI Architecture of a defuzzifier is proposed. The proposed architecture is based on the centre of gravity defuzzification method and implemented in tanner tool. The COG method is the most prevalent and physically appealing of all the defuzzification methods. By using the fuzzy inference processor process will speed up and efficiency also increases.

REFERENCES

[1] L. A. Zadeh, “Fuzzy sets”, Information and Control, Vol. 8, pp. 338-351, 1965.

[2] T. J. Ross, “fuzzy logic with engineering applications," by John Wiley Sons inc., 2005.

[3] E. H. Mamdani, “Applications of fuzzy algorithm for simple dynamic plant”, Proc. Inst. Elect. Eng., Vol. 121, pp. 1585-1588, 1974.

[4] C. C. Lee, “Fuzzy logic in control systems: fuzzy logic controller-part I”, IEEE Trans. Syst., Man. Cybern., Vol. 20, no. 2, pp. 404-418,1990.

[5] A. M. Murshid, S. A. Loan, S. A. Abbasi, and A. M. Alamoud, “VLSI Architecture of Fuzzy Logic Hardware Implementation: a Review,"Int. Journal of Fuzzy Systems, Vol. 13, No. 2, pp. 74-88, June 2011.

[6] H. Watanabe, W. D. Dettloff, and K. E. Yount, “A VLSI fuzzy logic Controller with reconfigurable, cascade architecture”, IEEE Journal of Solid-State Circuits, Vol. 25, pp. 376-381, 1990.

[7] A. M. Murshid, S. A. Loan, S. A. Abbasi, and A. M. Alamoud, “A novel VLSI architecture for a fuzzy inference processor using Triangular-shaped membership function," int. Journal of fuzzy Systems, vol. 14, no. 3, pp. 345-360, sep. 2012

[8] Sajad A. Loan,“A Noval VLSI Architecture Of Weighted Average Method Based Defuzzifier Unit” International Multi Conference of Engineers and Computer Scientists 2014 Vol II,IMECS 2014, March 12 – 14

[9] Anas Fattouh and Fadifouz,”Atwo Stage Representation Of Fuzzy Systems” International Journal Of Engineering Research and Applicationvol.2, Issue3, May –June 2012, Pp.2660-2665.